Testing Semiconductors with a VOM

BY SAM GUCCIONE, K3BY

Would you believe that, using a standard VOM (volt-ohm-ammeter), a 100-ohm resistor, and a 1.5-volt flashlight battery, a quick GO/NO-GO test can be performed on many semiconductor devices? It's true, and **Tables 1** through **5** show the test set-up and dc resistance response for more than a dozen semi-conductor devices.

Almost any standard type of VOM, except the digital models, may be used. However, one caution should be observed: The VOM is used as an ohmmeter in these tests, and a battery is needed in the ohmmeter circuit, to polarize the test leads. Thus, one lead is defined as positive and the other, of course, negative. In the popular Simpson 260 meter, the "COM" jack is the negative lead and the "V/A" jack is the positive lead. On the other hand, in the Micronta 22-203 VOM, the "COM" jack is the positive lead and the "VΩA" jack is the negative lead.

It's easy to determine the polarity of your VOM. Obtain a good semi-conductor diode, and identify the banded, or cathode, end. Set the ohmmeter to the R times 1 (R × 1) or the R times 10 (R × 10) range. Then, connect the lead from the "COM" jack to the cathode end of the diode, and connect the other lead to the anode end of the diode. If the meter goes to a low resistance reading, then the "COM" jack of your meter is truly negative and the other jack is positive. If the meter does not move or indicates a very high resistance, reverse the leads. The meter should show a low resistance. Now the "COM" jack of your meter is conected to the anode, and the other to the cathode. The lead connected to the anode is the positive lead, and the lead connected to the cathode is the negative lead.

Now that you have your VOM leads properly identified, you are ready to begin testing. Whenever a 1.5-volt cell is required, any size from A to D will do.

Let's look at some of the tests in the **Tables**. Your VOM should be set on the R × 1 or R × 10 range. **Table 1** shows the tests for seven diodes. Since many of the other devices are essentially diodes in one form or another, the semi-conductor diode is listed first because it is the easiest to test. The meter-indication column contains the expected meter indication for a good device. For example, when the VOM is connected as shown in (**a**) under the Test Set-Up column, a good diode will show a low resistance (on the R × 1 or R × 10 range) but not zero. If the indication is zero ohms, the diode is shorted.

Then, reversing the VOM as in (**b**) will produce a high resistance (on the R × 1 or R × 10 range), but not infinite ohms. If the indication is infinite, then the diode is open.

TABLE 1 DIODE TESTS

DEVICE	TEST SET UP	METER INDICATION
DIODE (A) ANODE (K) CATHODE	A) A K VOM +/− B) A K VOM −/+	A) LOW B) HIGH
DIAC	A) VOM +/− B) VOM −/+	A) HIGH B) HIGH
LED (A) ANODE LIGHT	A) A K 100 1.5V +/− B) A K 100 1.5V −/+ NO LIGHT LIGHT	A) LIGHT FROM LED B) NO LIGHT FROM LED
SCHOTTKY BARRIER AND MICROWAVE	CAN NOT TEST BY THIS METHOD	NONE
TUNNEL DIODE (A) ANODE (K) CATHODE	A) A K VOM +/− B) A K VOM −/+	A) LOW B) HIGH
VARICAP OR VARACTOR (A) ANODE (K) CATHODE	A) A K VOM +/− B) A K VOM −/+	A) LOW B) HIGH
ZENER (A) ANODE (K) CATHODE	A) A K VOM +/− B) A K VOM −/+	A) HIGH B) LOW

Table 1. Diode tests.

TABLE 2 BIPOLAR JUNCTION TRANSISTOR TESTS

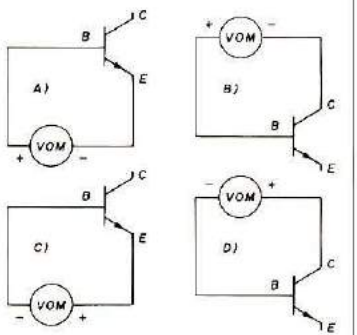
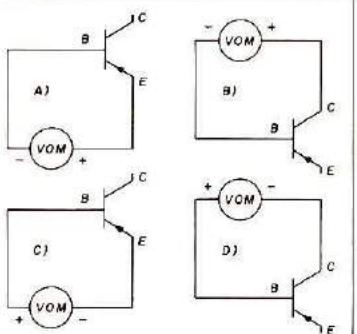
DEVICE	TEST SET UP	METER INDICATION
BJT - NPN COLLECTOR (C) (B) BASE (E) EMITTER		A) LOW B) LOW C) HIGH D) HIGH
BJT - PNP COLLECTOR (C) (B) BASE (E) EMITTER		A) LOW B) LOW C) HIGH D) HIGH

Table 2. Bipolar junction transistor tests.

The DIAC, or bidirectional trigger diode, requires a fairly high voltage to make it work. An ohmmeter cannot supply a large enough voltage to test the DIAC. The LED, light emitting diode, is tested by simply applying 1.5 volts to the diode. The 100-ohm resistor is absolutely necessary, or the diode will be burned out because of high current. If the LED does not show visible light with the battery connected either way, it is bad and should be thrown away.

Special high frequency diodes such as the PIN, Schottky, and microwave types should not be tested using a VOM. These diodes will be damaged by the voltages present in this hookup.

The last three diodes in **Table 1** can be tested as regular diodes. However, this dc test will not measure the special characteristics of each of these diodes. A curve tracer or other such device must be used. This simple dc test will merely show whether the device is burned out.

Table 2 shows the NPN and PNP bipolar transistor. The NPN and PNP transistors are essentially diodes connected end-to-end so that the test consists of testing two diodes. Connections at (a) and (c) are for the base-emitter diode, and (b) and (d) are the tests for the base-collector diode.

The junction field-effect transistor (jfet) requires 1.5 to 4.5 volts to see if it is working. Notice the polarity of the battery: A negative voltage is required on the gate of an N-Channel jfet to cause it to have a high resistance between drain and source. The gate must be connected to the source to get a low-resistance indication. A word of caution about some fets: the metal oxide semi-conductor fet (mosfet) should not be tested using this method. The mosfet is extremely susceptible to voltage transients, such as static discharges. Thus, more than likely, a mosfet will be burned out by testing using a VOM and battery. **Table 3** shows the two types of mosfets: the DE (depletion-enhancement) and E (enhancement). Mosfets are sometimes called igfets, which stands for insulated gate field-effect transistors.

Table 4 shows three devices which I call three-lead switching devices. The first one is the SCR, or silicon controlled rectifier. The SCR latches when voltage is applied to the gate; the meter indication is high until the

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T-106	135			1.06	1.50
T-80	55	45		.80	.80
T-68	57	47	21	.68	.65
T-50	51	40	18	.50	.55
T-25	34	27	12	.25	.40

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F-125	900	300	1.25	3.00
F-87	600	190	.87	2.05
F-50	500	190	.50	1.25
F-37	400	140	.37	1.25
F-23	190	60	.23	1.10

Chart shows uH per 100 turns.

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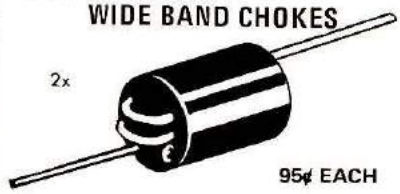

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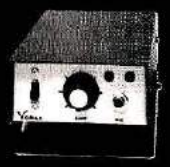

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TABLE 3 FIELD EFFECT TRANSISTOR TESTS

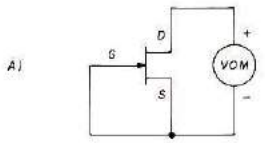
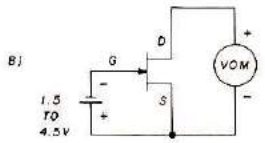
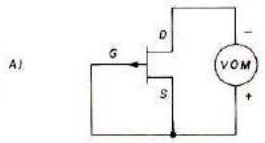
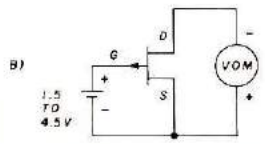
DEVICE	TEST SET UP	METER INDICATION
JFET - N CHANNEL DRAIN (D), GATE (G), SOURCE (S)	A)  B) 	A) LOW B) HIGH
JFET - P CHANNEL DRAIN (D), GATE (G), SOURCE (S)	A)  B) 	A) LOW B) HIGH
MOSFET DRAIN (D), GATE (G), SOURCE (S) DRAIN (D), GATE (G), SOURCE (S)	SHOULD NOT BE TESTED BY THIS METHOD	NONE

Table 3. Field effect transistor tests.

battery is momentarily connected to the gate, then the meter goes low and stays low even with the battery disconnected. The battery should not be connected to the gate without the resistor.

The TRIAC, or triode ac switch, is identical to the SCR except that the VOM can be connected to MT2 or MT1 either way.

The UJT (unijunction transistor) is included here, instead of in **Table 2**, since it is used almost exclusively as a switching device. The UJT is tested in the same way as the SCR, but it does not latch like an SCR; that is, the meter will read low only when the battery is connected.

By adding appropriate impurities, manufacturers can cause semi-conductor material to have a resistance that varies in a special way. **Table 5** contains three popular devices. The first is a light dependent resistor (LDR), or photocell. It can be thought of as a light-sensitive resistor. The more light that shines on the photocell, the lower its resistance.

A thermistor is a thermally sensitive resistor. The resistance will vary depending upon the type of thermistor. Some are negative-temperature-coefficient thermistors, which means the resistance increases with increasing temperature. The VOM should show some measurable value. When the thermistor is heated, the resistance should change.

The last item in **Table 5** is the voltage-dependent resistor (VDR), or varistor. The resistance of a varistor changes with the voltage applied to it.

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TABLE 4 THREE-LEAD SWITCHING DEVICES

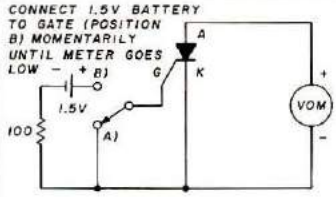
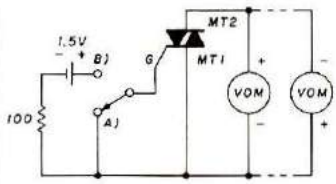
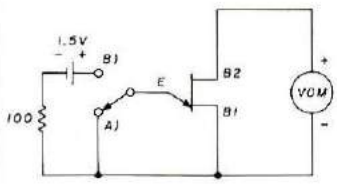
DEVICE	TEST SET UP	METER INDICATION
SCR		A) HIGH B) METER WILL GO LOW AND STAY LOW EVEN WITH BATTERY DISCONNECTED
TRIAC		A) HIGH B) METER WILL GO LOW AND STAY LOW EVEN WITH BATTERY DISCONNECTED
UJT		A) HIGH B) METER WILL GO LOW ONLY WHEN BATTERY IS HELD CONNECTED TO EMITTER

Table 4. Tests for three-lead switching devices.

TABLE 5 TESTING SEMICONDUCTOR RESISTANCES

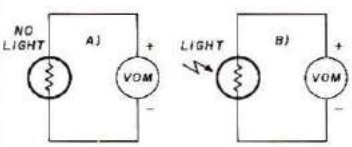
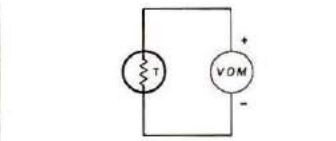
DEVICE	TEST SET UP	METER INDICATION
PHOTO CELL OR LDR		A) HIGH WITH NO LIGHT SHINING ON PHOTOCELL B) LOW WITH LIGHT SHINING ON PHOTOCELL
THERMISTOR		A) METER WILL HAVE MEASURABLE VALUE IF THERMISTOR IS GOOD
VARISTOR OR VDR		CAN NOT BE TESTED BY THIS METHOD — NONE

Table 5. Testing semi-conductor resistances.

A varistor cannot be checked with an ohmmeter.

The preceding tables contain simple dc tests for eighteen popular semiconductor devices, which should include the most common types you are likely to find in use today. In addition to making it possible to troubleshoot defective gear, these tests will enable you to sort through that bargain-priced bagful of goodies that you bought at the flea market or through a mail-order firm. It might be a good idea to make copies of the Tables, and hang them near your test setup or workbench for ready reference when you need the information in a hurry.

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